6. ECONOMIC IMPLICATIONS OF RETROFITTING SHORT-DUCT DC-8 AIRPLANES WITH ACOUSTICALLY TREATED NACELLES

By H. D. Whallon

McDonnell Douglas Corporation

SUMMARY

An investigation was conducted to determine the economic implications of retrofitting short-duct DC-8 airplanes with acoustically treated nacelles. The study compared each existing and modified model in terms of (1) annual profit and loss criteria, including taxes and profit after taxes, (2) investment, and (3) return on airplane investment. Estimates of the costs of developing, producing, and installing the treated nacelles were used as a basis for these comparisons. The effects on direct operating cost of the expected airplane performance changes and of amortization of the modification costs were also included in these estimates.

The study indicated that direct operating cost would be increased between 4 and 5 percent, assuming a 5-year amortization of the retrofit cost and modification of all short-duct DC-8 airplanes. The increase in direct operating cost would be due almost entirely to amortization of the costs of modification. On the assumption that operating revenues would be the same for the existing and treated airplanes, calculation indicated that profit after taxes and Federal income taxes would be reduced 10.1 percent for 5 years, the investment book value of airplane inventory would be increased 18.5 percent, and the discounted cash flow rate of return on airplane investment would be reduced 8.2 percentage points, about a one-quarter reduction from the existing level.

INTRODUCTION

This paper is part of a presentation of the results of an investigation performed under Contract NAS 1-7130 for the Langley Research Center by the McDonnell Douglas Corporation of DC-8 nacelle modifications to reduce fan compressor noise in airport communities. In this paper are examined the economic implications of retrofitting a fleet of DC-8 series 50 and model 61 airplanes with acoustically treated nacelles. These airplanes are equipped with JT3D engines and short-duct nacelles and constitute about 50 percent of the total DC-8 airplane fleet.

Studies were made of (1) a program schedule for a fleet retrofit, (2) the initial prices of retrofit kits needed to accomplish the modifications, (3) the changes in direct operating costs due to the modifications, and (4) the effects of retrofitted-fleet operations

on profit and loss criteria, investment, and return on airplane investment. In order to perform these studies, it was necessary to make a number of assumptions regarding basic factors that are uncertain at this time. Ultimately, each operator should assess the assumptions and make such adjustments as are necessary to fit the particular circumstances of his operations.

DISCUSSION

Assumed Retrofit Program Schedule

The assumed retrofit program schedule is outlined in figure 1. A 5-year overall program was assumed. The 5-year program shown would provide for retrofit installation of the modified nacelles on airplanes during scheduled engine or airplane overhauls and, thus, would require no out-of-service time for installation. The first 2 years of the program are necessary for development, tooling, and certification. The third through the fifth years of the program encompass retrofit kit production and installation.

Retrofit Price

About 250 short-duct DC-8 airplanes are expected to be in service in the early 1970's. Retrofit prices were estimated on the basis of 300 airplane kits to be produced in the years 1972 through 1974, which assumes retrofit of the total 250 airplanes and includes a 20-percent allowance for spares. The elements of the price estimate are indicated in table I. Values were initially estimated on the basis of current rates and were then escalated 4 percent per year to 1972. The estimated 1972 values would have to be adjusted if the number of kits, the time period, or the escalation factor differed from the foregoing assumptions.

Development and tooling represent estimated non-recurring or fixed costs, whereas manufacturing represents the estimated recurring or variable per-kit cost of production at the 300-unit level of production. The total price per kit installed was estimated to be $546 000. With 20 percent spares, the total price per airplane would be $655 000.

Figure 2 illustrates the variation of kit unit price with the number of airplane kits to be produced. The larger the base over which the non-recurring costs are allocated, the lower the per-unit price of the airplane kit. The curve also reflects some economies of scale and improvements in production efficiency with quantity.

Direct Operating Cost

Another element to be assessed is the effect of the modification on the operating costs of the airplane. This effect was determined by comparing the direct operating costs (DOC) of the existing airplane with those of the same airplane after nacelle modification.

The change in the DOC of the airplane which would result from the retrofit was calculated on the basis of the retrofit price discussed in the previous section, the changes in airplane performance described in paper no. 4 by David K. Gordon, and some basic assumptions as indicated in table II. The standard 1967 Air Transport Association (ATA) method was used as the basis for calculating direct operating costs (ref. 1). However, certain modifications in the method were made and certain values were assumed to reflect the specific nature of the retrofit program.

Installed price of the retrofit modification was $546 000 per airplane (without spares). The price of the existing airplane would be increased by the price of the retrofit kit installed. Standard spares factors of 10 and 40 percent, respectively, were used for airframe and engines; a nonstandard 20 percent spares factor was introduced for the nacelle parts, corresponding with spares practice on quick engine change components. The standard depreciation period of 12 years was used for the airplane; the added price of the nacelle modifications, however, was depreciated over a 5-year period. This implies the assumptions that the airplane is retrofitted at the end of its seventh year of service and that depreciation of the additional investment in the retrofit nacelles coincides with the last 5 years of airplane service life. Fixed, rather than variable, utilization of 3800 hours was used. A typical mixed-class interior configuration of 135 seats was assumed for the DC-8-55 airplane. Only this assumption is peculiar to the model 55 airplane, as shown in table II, and it illustrates that a representative domestic passenger configuration was assumed for each short-duct DC-8 model. Zero downtime was assumed for retrofit-kit installation, in the expectation that installation could be phased with normally scheduled downtime for maintenance. Finally, the change in nacelle maintenance cost due to the modification was estimated by task analysis, although the basic existing nacelle maintenance costs were calculated by the ATA method.

Based on the airplane modification costs and the approach and assumptions discussed, the DOC of the existing and treated DC-8-55 airplanes would be as shown in figure 3. The direct operating cost is in terms of cents per seat nautical mile, and the range is given in nautical miles. The solid-line curve is the DOC of the existing unmodified airplane; the dash-line curve is the DOC of the same airplane with treated nacelles.

The modification increases the airplane's DOC between 4 and 5 percent in the customary operating ranges below the discontinuities of the DOC curves. The 3-percent increased range of the airplane with treated nacelle, discussed in paper no. 4, is reflected by the greater range at which the discontinuity occurs for the modified airplane.

Table III shows a breakdown of the elements that constitute the change in DOC shown in figure 3. The change in each element is shown as a percent of DOC. The example shown is for domestic passenger service at an 850-nautical-mile range and a 5-year

depreciation of the retrofit. Crew cost did not change, since block time was not perceptibly changed by the modification. Insurance increased; this reflected the increased book value of the airplane after the modification. Fuel cost decreased; this reflected the improved cruise fuel consumption of the modified airplane.

Maintenance was estimated by task analysis to increase about 1 dollar per flight hour, or about one-tenth of 1 percent of DOC. This preliminary estimate is subject to change when additional experience is accumulated on the service life, inspection and repair costs, and cleaning costs associated with the acoustic materials that would be used. The changes in insurance, maintenance, and fuel cost approximately cancel each other.

The change in depreciation, which is due to amortization of the added cost of the modification, was found to be the dominant element of the overall net change in DOC.

Economic Analysis

DC-8-55 airplane.- To evaluate the financial aspects of the retrofit, comparisons were made between the existing and treated airplanes as though each were operating under the same average service conditions and assumptions. Preliminary studies indicated that profit and loss calculations based on an average range of 850 nautical miles resulted in average operating revenues, costs, and profits and in valid economic comparisons between the two airplanes. Particular assumptions used in the economic analysis are listed in table IV.

The revenue-earning capability of the airplane with treated nacelle was assumed to be the same as that of the existing untreated airplane. (See paper no. 4.) Not evaluated were the increased payload-range capability or the possibilities of earlier retirement, changes in route structure, and changes in airplane task assignment. Both airplanes were assumed to perform the same service task and to earn the same revenue. Revenue calculations were based on published air fares as of May 1969. Although it is recognized that fares might be increased to accommodate the increased operating costs of the modified airplane, this factor was not treated in the study.

Both airplanes were in passenger service, both operated at a 50-percent load factor, and both had the same indirect operating costs, calculated at 42 percent of revenue. The cost of the retrofit was treated as an increase in capital investment rather than as an expense. The same 48-percent corporate income tax rate was applied to the operations of both airplanes, and the investment tax credit was treated as zero in synthesizing each airplane's profit and loss status.

Table V shows the changes resulting from the modification in 1 year's profit and loss criteria. Revenue was not changed and operating expenses, except for depreciation, were likewise unchanged. Depreciation increased to amortize the cost of the modification,

and the increase in depreciation was the only perceptible change in operating expenses, as previously noted. The increased depreciation caused an equivalent reduction in profit before taxes. Of the reduction in profit before taxes, 48 percent was absorbed by a decrease in income taxes paid and the balance came out of profit after taxes. In effect, the Government absorbed 48 percent of the cost of retrofit, and operations bore 52 percent of the cost. Annual cash flow, which is the sum of depreciation and profit after taxes, increased since the increase in depreciation was greater than the decrease in profit after taxes.

Table VI shows the changes in airplane investment and return on airplane investment. Investment was calculated to be the depreciated value of the airplane at the time of retrofit, which was assumed to be at the end of the seventh year. Investment was increased by $655 000, the cost of the retrofit plus spares.

Return on airplane investment was calculated to be the discounted cash flow rate of return on airplane investment over the economic life of the investment, which in this study is 5 years. Return on airplane investment was reduced 6 percentage points. The investment increased relatively more than did the cash flow, which decreased the rate of return.

DC-8 short-duct fleet.- The operational service analysis in the preceding section dealt with only one of the six short-duct DC-8 models. A similar analysis was performed on each of the other five models. The results for the six models were combined to evaluate the effect of the total fleet retrofit.

Table VII shows the estimated composition of the short-duct DC-8 fleet at the start of 1972. About 250 short-duct DC-8 airplanes are estimated to be in service on January 1, 1972. The model 61 is the only short-duct DC-8 airplane presently in production, and deliveries by the start of 1972 may differ from the estimate of 101 shown. Attrition and retirement are additional unpredictable factors that make the total of 250 airplanes a working estimate only.

The economic effects were different for each model. Generally, the economic impact was the least severe for the largest and most profitable model, the extended-fuselage DC-8-61. Table VIII summarizes the overall economic impact of retrofitting the entire mixed fleet of 250 short-duct DC-8 airplanes. Profit after taxes was reduced 10.1 percent, investment book value of airplane inventory was increased 18.5 percent, and the rate of return on airplane investment was reduced by 8.2 percentage points, about a one-quarter reduction from the rate of return of the existing unmodified fleet.

CONCLUDING REMARKS

The economic effects of retrofitting DC-8 short-duct airplanes with acoustically treated nacelles were examined in this paper. The cost of retrofitting 250 airplanes was estimated to be $655 000 per airplane. Direct operating cost would be increased 4 to 5 percent.

On the basis of the assumptions that the retrofit program would not affect revenues, scheduling, utilization, route and traffic assignment, or remaining economic life and retirement plans for the airplanes, it was estimated for the total short-duct DC-8 fleet that profits (and Federal income taxes) would be reduced 10.1 percent for 5 years, investment book value of aircraft inventory would be increased 18.5 percent, and the discounted cash flow rate of return on aircraft investment would be reduced 8.2 percentage points, a one-quarter reduction from the existing level.

The economic effects determined in this program apply only to DC-8 airplanes with short-duct nacelles. The total DC-8 fleet in 1972 is expected to include not only the 250 short-duct DC-8 airplanes discussed but also an approximately equal number of other DC-8 models, including turbojet engines and long-duct nacelle installations to which these study results do not apply.

The economic impact on individual operators and on the industry as a whole as a result of retrofitting existing airplanes with acoustically treated nacelles warrants further study in which consideration can be given to factors such as fleet reequipment plans, possible changes in airplane traffic and route assignments, possible changes in fares, and future local, federal, and international noise regulations.

REFERENCE

1. Anon.: Standard Method of Estimating Comparative Direct Operating Costs of Turbine Powered Transport Airplanes. Air Transp. Assoc. Amer., Dec. 1967.

TABLE I

RETROFIT-KIT PRICE
[BASIS: 300 AIRPLANE KITS FOR 250 AIRPLANES]

ELEMENT	PRICE, 1972 DOLLARS
DEVELOPMENT	52 000
TOOLING	11 000
MANUFACTURING	480 000
INSTALLATION	3 000
SUBTOTAL (PER AIRPLANE KIT)	546 000
SPARES	109 000
TOTAL (PER AIRPLANE)	655 000

TABLE II

ASSUMPTIONS USED IN DOC CALCULATIONS
[DC-8-55]

PRICE OF RETROFIT LESS SPARES, 1972 DOLLARS	546 000
SPARES FACTOR, PERCENT	
AIRFRAME	10
ENGINES	40
RETROFIT-KIT	20
DEPRECIATION PERIOD, YEARS	
AIRFRAME	12
NACELLE MODIFICATIONS	5
UTILIZATION, HOURS/YEAR	3 800
SEATS	135
DOWNTIME, HOURS	0
NACELLE MAINTENANCE INCREMENT	TASK ANALYSIS

TABLE III

DIRECT OPERATING COST CHANGES

[DC-8-55; DOMESTIC RULES; 850 n. mi. RANGE]

ELEMENT	DOC, PERCENT
CREW	0.0
INSURANCE	+0.3
FUEL	-0.5
MAINTENANCE	+0.1
DEPRECIATION	+4.3
NET CHANGE	+4.2

TABLE IV

ASSUMPTIONS USED IN ECONOMIC ANALYSIS

ITEM	ASSUMED VALUE
REVENUE	UNCHANGED
SERVICE	PASSENGER
LOAD FACTOR, PERCENT	50
INDIRECT OPERATING COST, PERCENT OF REVENUE	42
FINANCIAL TREATMENT OF RETROFIT COST	INVESTMENT
CORPORATE TAX RATE, PERCENT	48
INVESTMENT TAX CREDIT, PERCENT	0

TABLE V

PROFIT AND LOSS

[DC-8-55; DOMESTIC RULES; 850 n. mi. RANGE]

	ANNUAL CHANGES PER AIRPLANE
OPERATING REVENUE	NONE
OPERATING EXPENSES LESS DEPRECIATION	NONE
DEPRECIATION	$ +131 000
PROFIT BEFORE TAXES	-131 000
INCOME TAXES	-63 000
PROFIT AFTER TAXES	-68 000
CASH FLOW	+63 000

TABLE VI

RETURN ON AIRPLANE INVESTMENT

[DC-8-55; DOMESTIC RULES; 850 n. mi. RANGE]

	EXISTING	TREATED	CHANGE
INVESTMENT	$3 590 000	$4 245 000	$655 000
RETURN ON AIRPLANE INVESTMENT	18 PERCENT	12 PERCENT	-6 PERCENTAGE POINTS

TABLE VII

ESTIMATED FLEET COMPOSITION
[SHORT-DUCT DC-8 AIRPLANES, JAN. 1, 1972]

DC-8 MODEL	QUANTITY
51	34
52	27
53	27
54	28
55	33
61	101
TOTAL	250

TABLE VIII

FIVE-YEAR IMPACT ON OPERATIONS OF TOTAL FLEET RETROFIT
[250 AIRPLANES]

CRITERIA	CHANGE
PROFIT AFTER TAXES, PERCENT	-10.1
INVESTMENT, PERCENT	+18.5
DISCOUNTED CASH FLOW RATE OF RETURN ON AIRPLANE INVESTMENT OVER THE 5-YEAR PERIOD, PERCENTAGE POINTS	-8.2

ASSUMED RETROFIT PROGRAM SCHEDULE
250 AIRPLANES

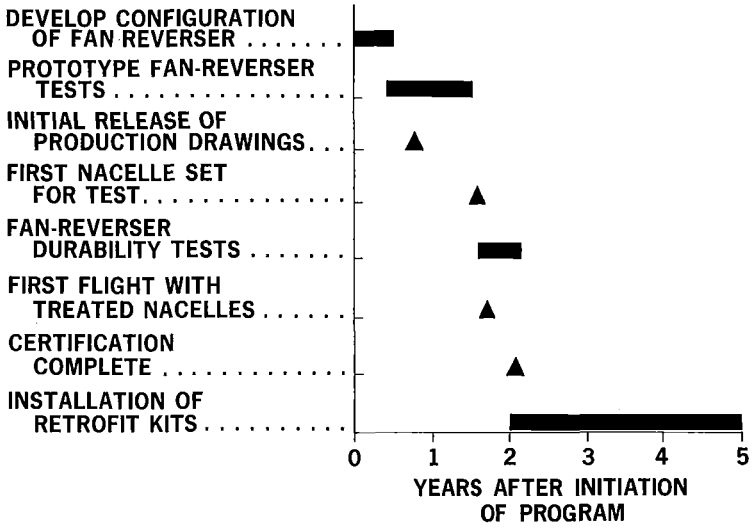

Figure 1

VARIATION OF RETROFIT-KIT PRICE WITH QUANTITY

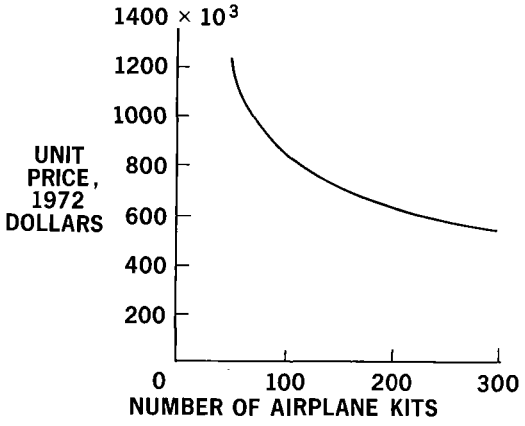

Figure 2

DIRECT OPERATING COST

DC-8-55; DOMESTIC RULES

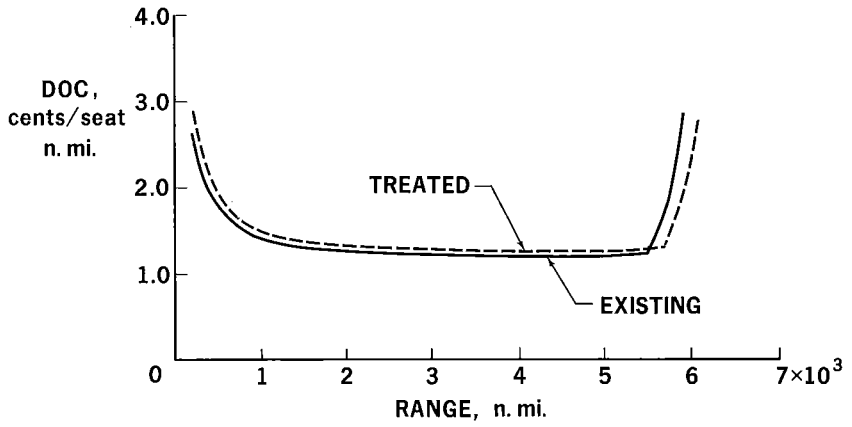

Figure 3